



“Large Scale PEM Electrolysis to Enable Renewable Hydrogen Fuel Production”

Alternative Energy NOW
2/10/10

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Report Documentation Page			Form Approved OMB No. 0704-0188		
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1. REPORT DATE 10 FEB 2010	2. REPORT TYPE N/A	3. DATES COVERED -			
4. TITLE AND SUBTITLE Large Scale PEM Electrolysis to Enable Renewable Hydrogen Fuel Production		5a. CONTRACT NUMBER FA8222-05-D-0001-0065			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S) Steve Szymanski		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Proton Energy Systems 10 Tchnology Drive Yalesville, CT 06492 USA		8. PERFORMING ORGANIZATION REPORT NUMBER 20537RC			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA		10. SPONSOR/MONITOR'S ACRONYM(S) TACOM/TARDEC			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) 20537RC			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the 4th annual Alternative Energy NOW Conference 9-10 February 2010, Orlando, FL, USA, The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 27	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Presentation Outline

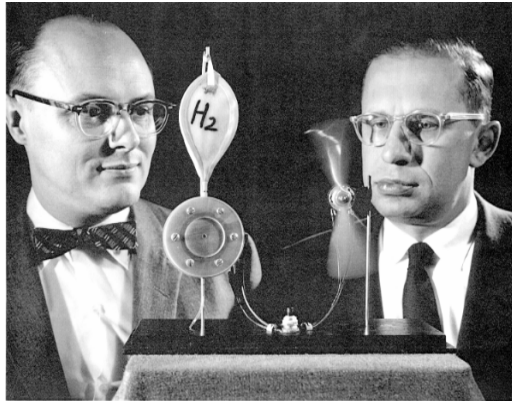
- Company overview
- Introduction to PEM electrolysis
- Development program overview and results
- New product platform launch

Proton Energy Systems

- World leader in PEM electrolysis
- Founded in 1996
- Located in Wallingford, Connecticut.
- ISO 9001:2000 registered
- Over 1,200 systems operating in 58 different countries.

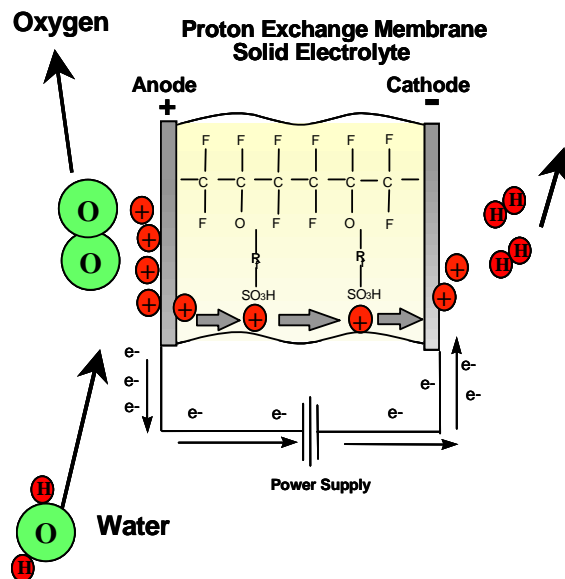


Development of PEM Electrolysis

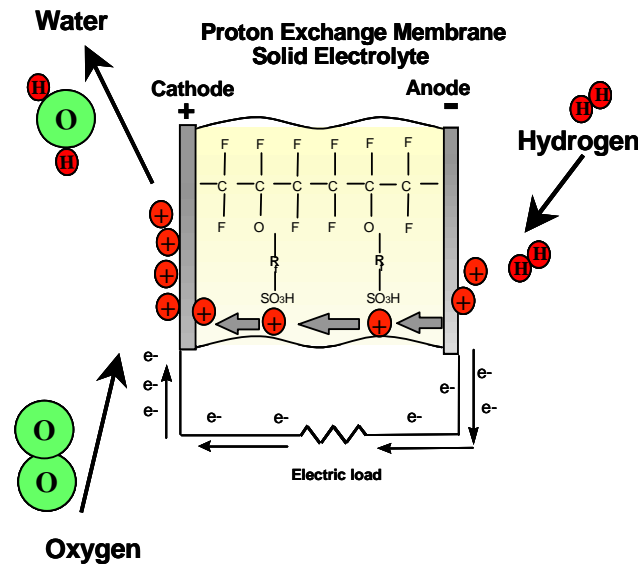


*Initial PEM innovators
Grubb & Neidrach,
GE Research, 1955*

PEM Electrolysis

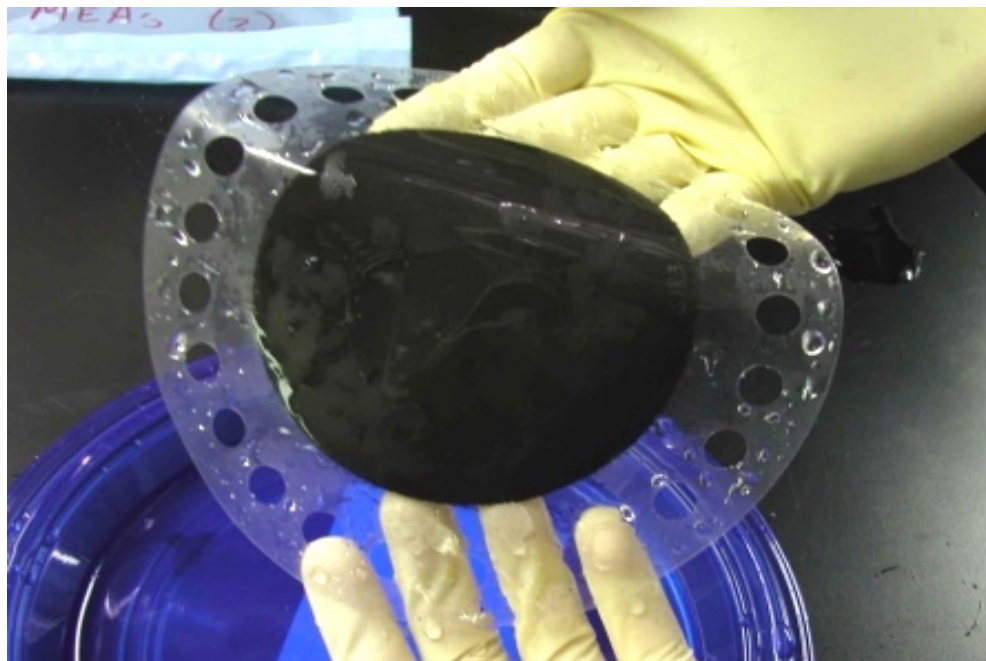


PEM Fuel Cell



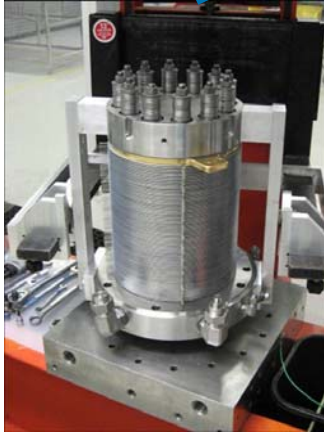
PEM (Proton Exchange Membrane)

...is at the heart of Proton's hydrogen generation technology



PEM Electrolyzer technology has a long history of reliability in critical military applications:

SSN and SSBN Submarine Life Support



Proton cell stack



Integrated Low Pressure Electrolyzer

Photo courtesy of Hamilton Sundstrand



**Virginia Class
Submarine**

Proton Capabilities

- Electrolysis System and Cell Stack R&D
- Product Manufacturing & Testing
- World-Wide Sales & Service
- Integration of electrolyzers into complete hydrogen solutions



**CELL STACK
MANUFACTURING**






**SYSTEMS
MANUFACTURING**



**CELL STACK
R&D**

Commercial Product Details

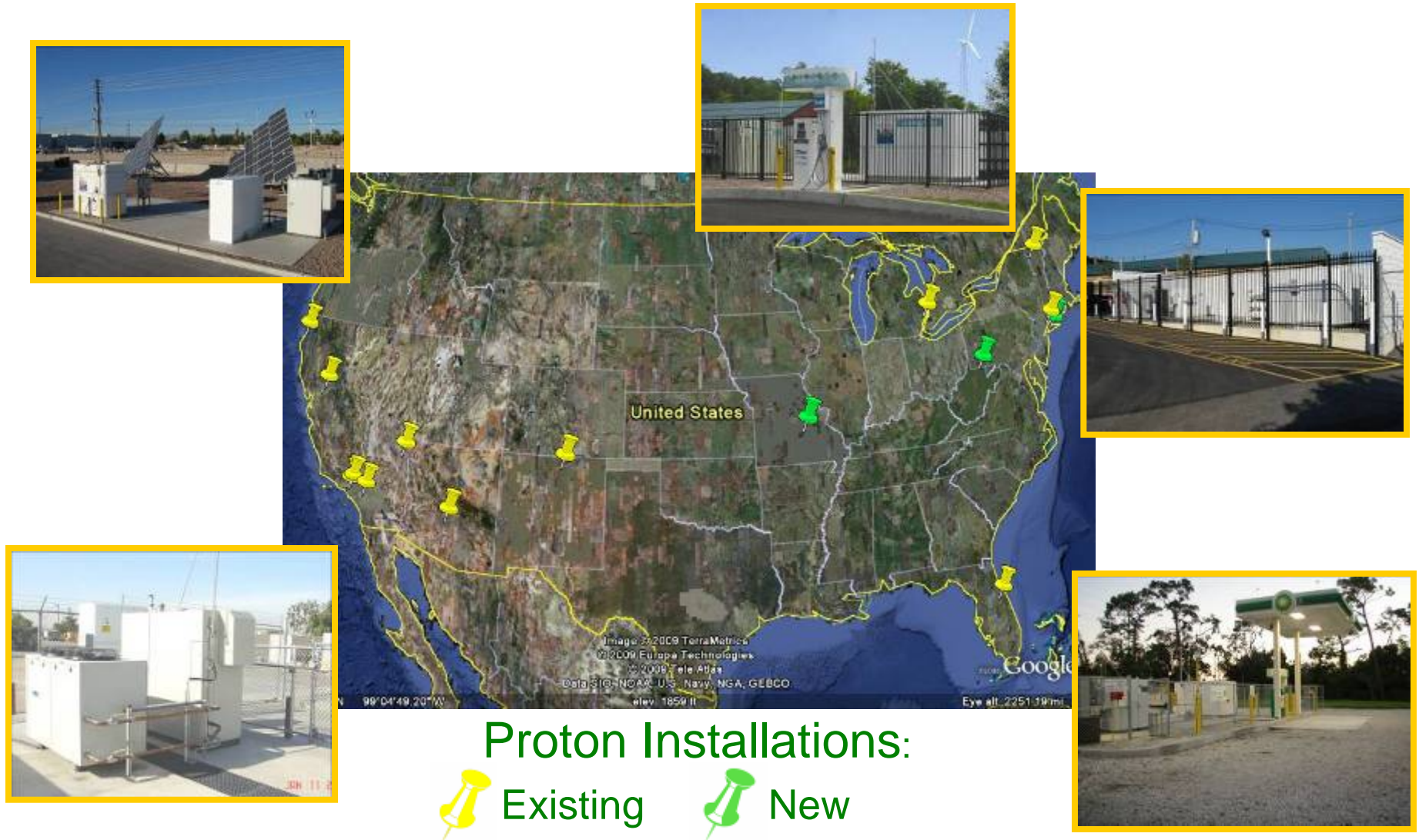
	HOGEN® GC Series	HOGEN® S-Series	HOGEN® H-Series
			
Year Introduced	1999	2000	2004
Applications	Laboratories	Industrial Gas Generation Meteorological Industries Fuelling Industries	Power Plants Heat Treating PCB Industries
Generator Rate	300 or 600 cc/min	0.5 to 1.0 Nm ³ /hr H ₂ 1-2 kg/day	2-6 Nm ³ /hr H ₂ ; 4-12 kg H ₂ /day
Hydrogen Pressure	Pressure to 13 bar	15 bar	15 & 30 bar
Ultra-High Pressure Hydrogen Purity	99.9999+%	99.9995+%	99.9995+%
Dimensions	23 x 37x 52 cm	97 x 79 x 106 cm	200 x 80 x 200 cm
Weight	23 kg	215 kg	700-800 kg

Hydrogen Industrial Markets

- Hydrogen is fastest growing industrial gas: 7%/year
- Major industrial gas consuming industries
 - Power plants
 - Semiconductor manufacturing
 - Flat panel computer and TV screens
 - Heat treating
 - Analytical chemistry
(pharmaceuticals, environmental testing)
- Distributor alliances drive market acceptance



Emerging Market: Hydrogen Fueling

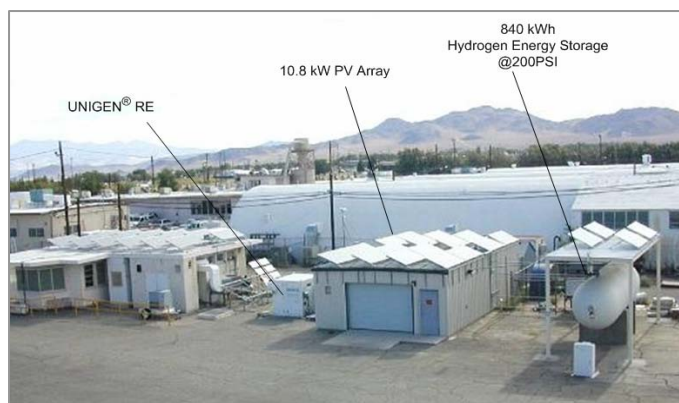


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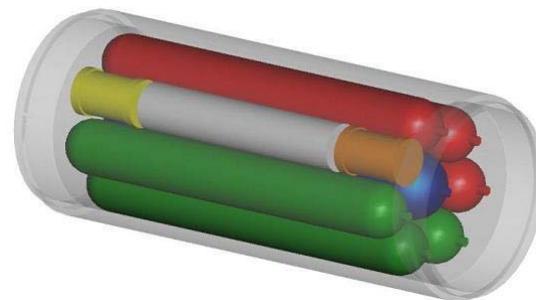
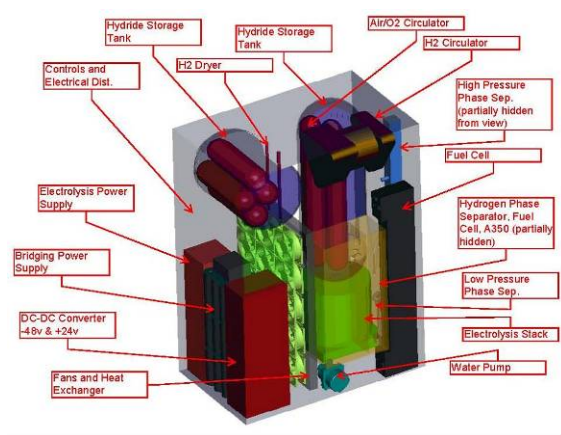
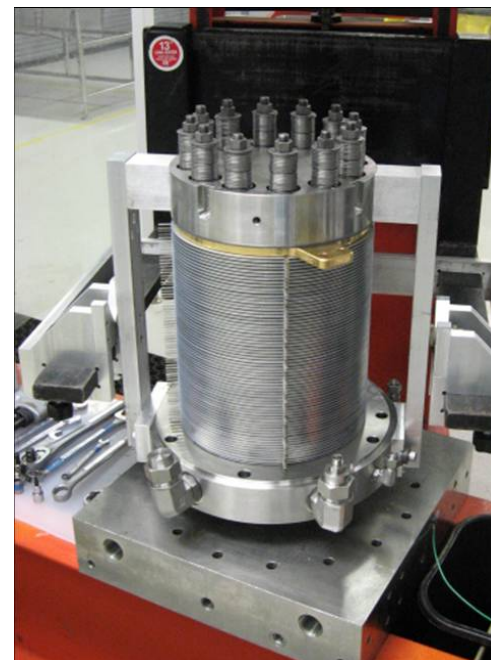
Emerging Market: Backup Power



Emerging Market: Renewable Energy Storage



Military and Aerospace Market



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Military and Aerospace Applications

Various military and aerospace applications are enabled by PEM electrolyzer technology:

- Unmanned underwater and aerial vehicles
- Remote camp energy storage
- Space based systems – lunar colonies and satellites
- Submarine life support
- Fueling of specialty vehicles



65 kg/day Fueling Platform Development Program Overview



- Prime Contractor: Select Engineering Services
- Period of Performance: Sept 2008 to Mar 2010
- Top level objective: scale up Proton's existing commercial hydrogen output by more than a factor of 5, simultaneously improving system efficiency and reducing the net cost/kg of hydrogen.

65 kg/day System Development (“C Series”): Work Plan Split

- TARDEC Program
 - Gas management system development and validation
 - Power supply development and prototype testing
 - Larger scale cell stack testing
- Proton IR&D
 - Controls, cell stack power supplies, AC/DC power distribution, safety system, cell stacks
 - Final integration and testing of 65 kg/day prototype

TARDEC program leverages cell stack development program for Navy life support

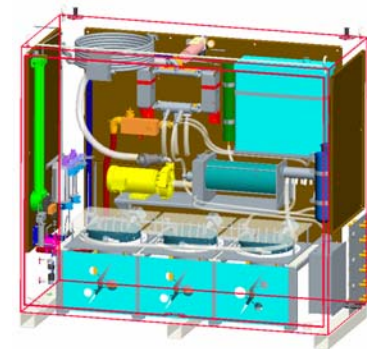
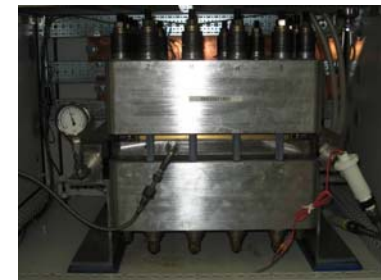
- Hamilton Sundstrand chose Proton to develop and manufacture cell stacks for its Navy customers (U.S. and U.K.)
- Proton completed design cycle in 18 months (through MIL-S-901D Shock and MIL-STD-167-1 Vibration qualification testing).
- High reliability stack platform ready for insertion into TARDEC supported BOP system.
- Enables new product launch (C-Series)



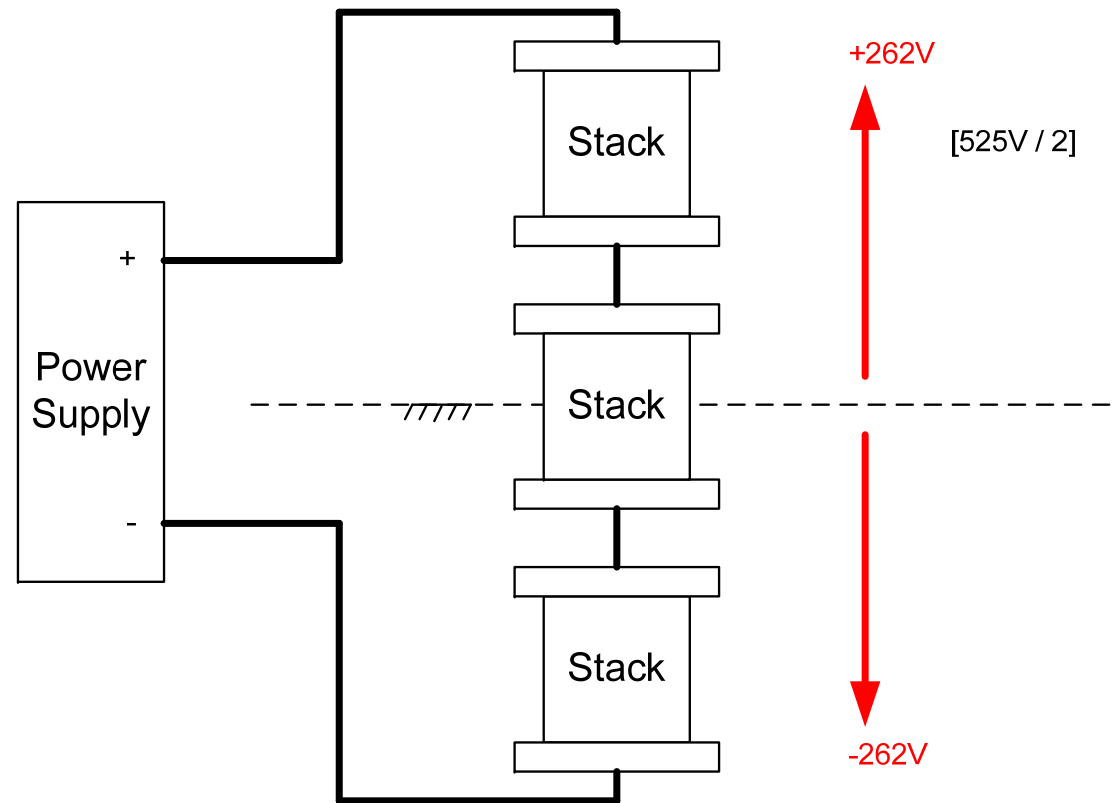
Proton PEM cell stack for UK Vanguard subs

TARDEC Program Elements

- 1.0 Power Supply
 - Develop and test full-size P/S with efficiency target of $\geq 94\%$.
 - Use FuelGen12 system as long-term test bed.
- 2.0 Bi-polar Plate Cell Stack
 - Test both 15 barg and 30 barg designs.
 - Verify scale-up from 0.1ft² to 0.6ft² for 3 cells.
 - Use DOE 0.6ft² test rig for validation.
- 3.0 Gas Management System
 - GMS being designed for and tested in a complete 65 kg/day system.
 - Net reduction in dryer losses from 10% to <2%.



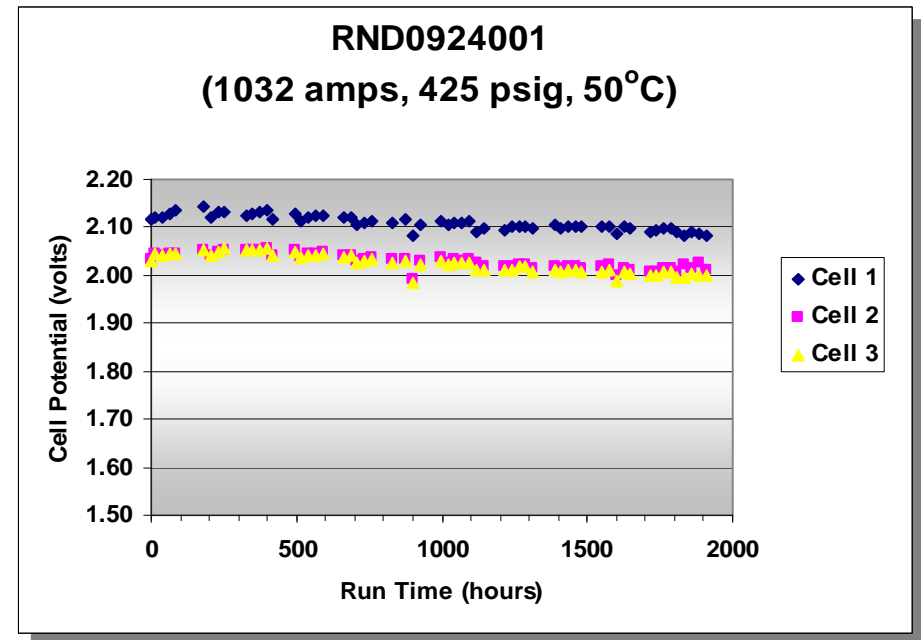
1.0 Power Supply Achievement: > 97% efficiency



The optimum power supply design resulted in powering cell stacks in series to achieve DC voltages near same range as AC voltages(525V).

2.0 Cell Stack Achievements

- Completed the 0.6 ft² short stack test stand.
- Assembled, tested and operated four separate cell stacks without any failures.
- Enables further scale-up of system to beyond 130 kg/day.

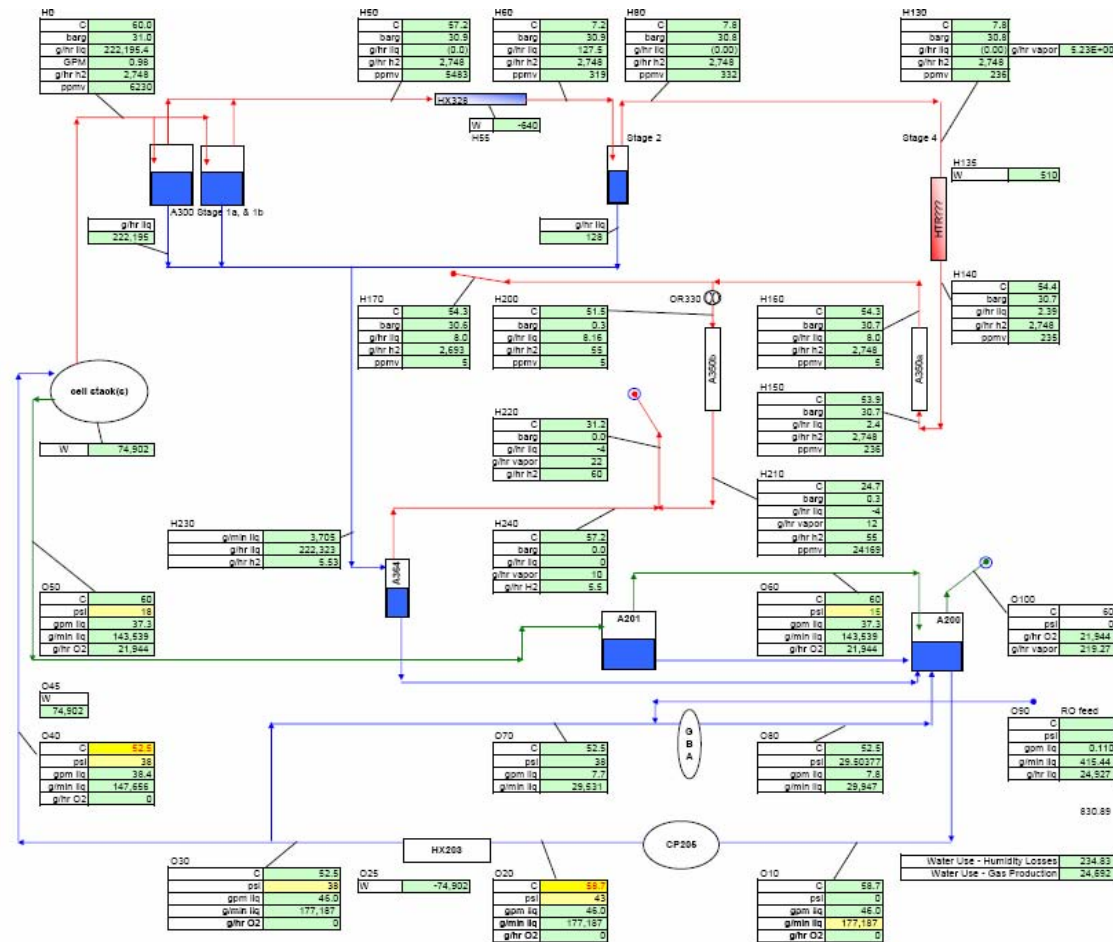


3.0 GMS operational test platform: functional 65 kg/day Electrolyzer

- Heavily instrumented to validate system model
- System modifiable/configurable to:
 - meet TARDEC goals
 - test component improvements
- Operating at full output (65 kg/day)
 - collecting operational data
 - verifying dryer loss target (<2%)

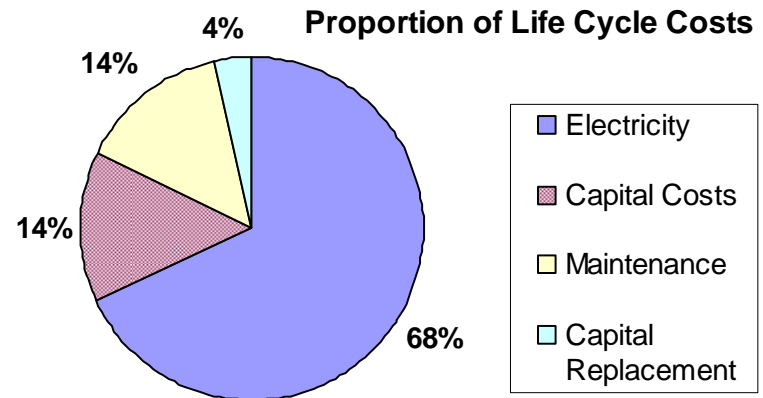


System Model – Validated by test program!!!

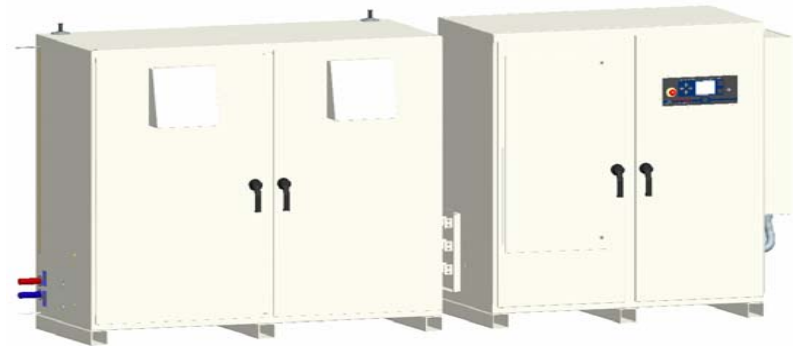


Program Accomplishments

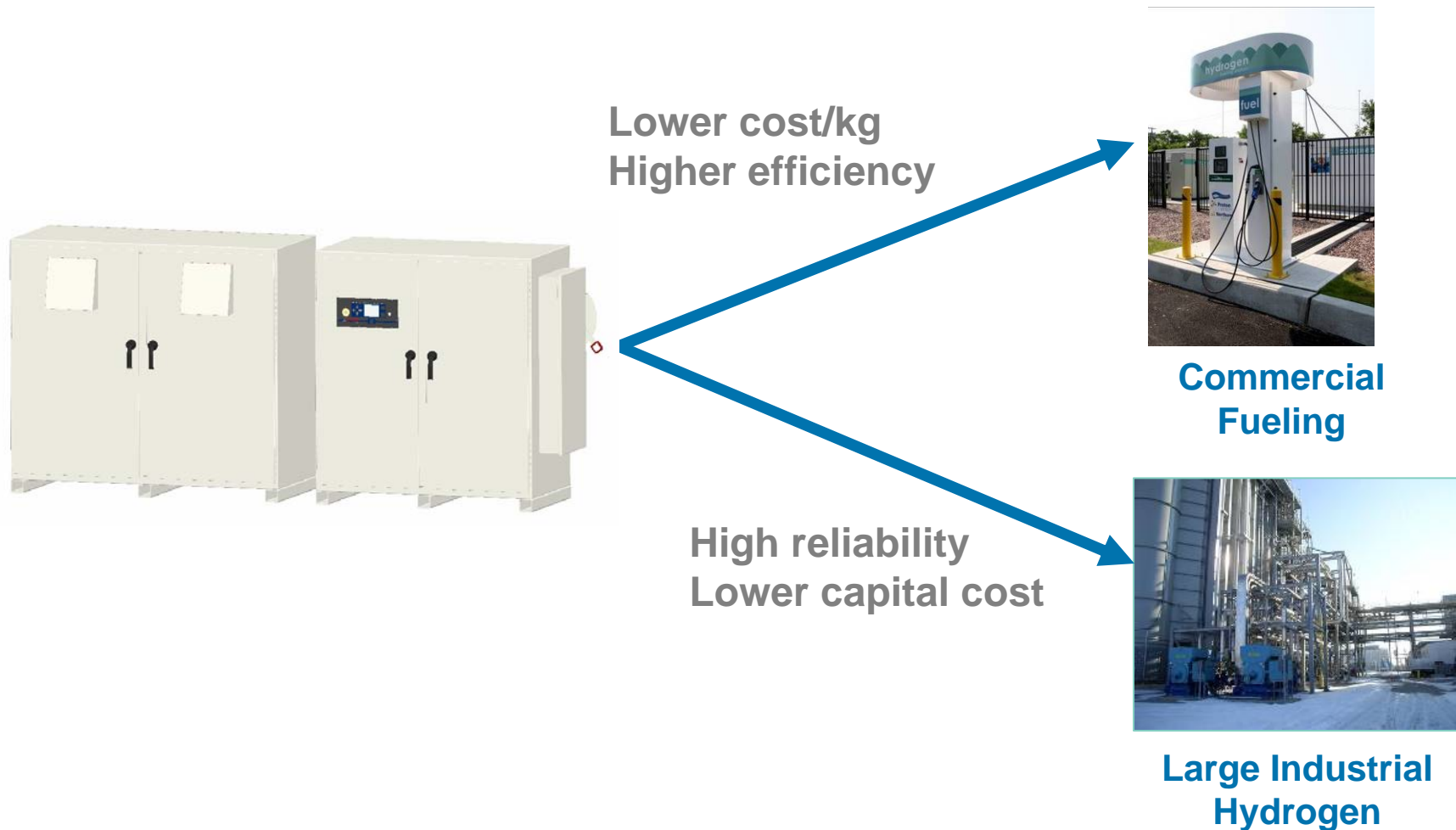
- Enables deployment of largest PEM electrolysis systems ever built.
- Accomplishes electrical efficiency improvements of nearly 14%.
- Validates projected cost targets of ~ \$5.00/kg H₂ for modest production volumes.
- Creates opportunities for zero emission fuel for vehicles in the TARDEC domain.
- Creates opportunities for immediate commercial sales to large industrial users of H₂.



H2A cost analysis validated



Net result is a product pathway that addresses both near term and emerging markets.

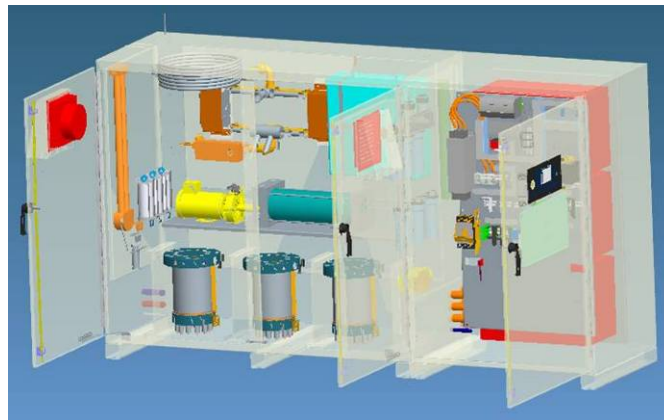


Program Value Demonstrated

- Net result is a validated electrolyzer system that offers high efficiency, low cost production of hydrogen fuel from renewable sources.
- Dual use capability of this system (fueling and industrial hydrogen) provides an immediate commercial outlet for this new platform.
- New larger cell stack platform offers the opportunity for further cost reduction and scale-up in future development program.

New electrolyzer platform enabled: HOGEN[®] C Series

- Maximum Capacity: 30 Nm³/hr H₂ (65 kg/day)
- Development cycle: 12 months to working prototype (12/09).
- Full Commercial availability: Q1 2011.
- 5 times the hydrogen output of the H-Series yet **only 1.5x the foot print.**
- Uses stack platform developed for Navy life support application and BOP design developed and validated under TARDEC program.
- Cooperative investment enables new product with broad application!



Next Step: Integration into containerized fueling package and field demonstration

- Proton designing a deployable fueling station configuration packaged in 40 foot ISO containers.
- Initial prototype to be sited on Proton property in Wallingford, CT (summer 2010).
- Configured for insertion of 65 kg/day electrolyzer developed under TARDEC program.
- Dual pressure (350/700 bar) fast fill dispensing.
- Evaluating potential sites for deployment of the packaged 65 kg/day station in a demo program (available for delivery in Q4 2010).